NPS54-82-004

NAVAL POSTGRADUATE SCHOOL

Monterey, California

EVALUATION OF MAINTAINABILITY ENHANCEMENT
FOR TCP/TSP REVISION 6.0 UPDATE .20

Norman F. Schneidewind

February 1982

Final Report: 1 Jan 80 to 1 Jan 82

Approved for public release; distribution unlimited

Prepared for:
The Trident Command and Control Systems Maintenance Agency
Newport, Rhode Island

NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral J. J. Ekelund
Superintendent

David R. Schrady
Acting Provost

The work reported herein was supported by the Trident Command and Control Systems Maintenance Agency.

This report was prepared by:

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NPS54-82-004	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): EVALUATION OF MAINTAINABILITY ENHANCEMENT FOR TCP/TSP REVISION 6.0 UPDATE .20	5. TYPE OF REPORT & PERIOD COVERED: Final Report, 1 Jan 80 to 1 Jan 82
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Norman F. Schneidewind	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Postgraduate School, Monterey, California 93940	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: N4216680WR00007
11. CONTROLLING OFFICE NAME AND ADDRESS: Trident Command and Control Systems Maintenance Agency, Newport, Rhode Island 02840	12. REPORT DATE: 22 February 1982
	13. NUMBER OF PAGES: 41
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Software maintenance	SECNAVINST 3560.1
Software maintainability	FIPS PUB 38
Software standards	MIL-STD 1679
Traceability	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A system of documentation which was designed to aid programmers of the Command and Control System Maintenance Agency (CCSMA) in maintaining the Trident Command and Control System software was evaluated. This system is called "Maintainability Enhancement for TCP/TSP Revision 6.0 Update .20" or simply 6.0/.20. It is essentially a hierarchical method of charting software procedures and the relationship between procedures. The difficulty of trying to overlay a structured documentation technique on programs which are inherently non-structured (written in low-level language and patched) is

discussed. Discrepancies which arose between the newly constructed charts and the original listings are highlighted. A conclusion of this study is that rather than improving clarity, applying structured documentation to non-structured programs may result in the opposite effect--incomplete, inconsistent, and ambiguous documentation--because a hierarchical format cannot adequately represent a non-hierarchical program.

SECNAVINST 3560.1 and MIL-STD 1679 (Navy) are considered by CCSMA to be relevant documents for maintenance purposes. Therefore, the documentation system was checked for conformance with applicable sections of 3560.1 and 1679. In addition, the documentation system was compared with applicable sections of FIPS PUB 38, published by the National Bureau of Standards. Although officially FIPS PUB 38 applies to ADP and not to embedded computer systems, it provides good guidelines for program documentation and maintenance. It was found that 6.0/.20 does not include coverage of many of the applicable sections of the three documents.

SUMMARY

Trident CCSMA requested the Naval Postgraduate School to evaluate the "Maintainability Enhancement for TCP/TSP Revision 6.0 Update .20," referred to as 6.0/.20. The approach for accomplishing this task was to compare 6.0/.20 for compliance or conformity with applicable sections of SECNAVINST 3560.1, FIPS PUB 38, AND MIL-STD 1679. In addition, a sample of 6.0/.20, Volume 2, was examined in some detail for its usefulness as a software maintenance tool in terms of consistency, completeness, understandability, and absence of errors. Many suggestions for improvement have been made.

Our conclusions are that 6.0/.20:

- Does enhance maintainability. However, we believe listings alone, even if they are structured, are inadequate for maintenance purposes.
- Does not include coverage of significant applicable items called for in 3560.1, FIPS PUB 38, and 1679.
- Appears to be incomplete and to contain a moderate amount of inconsistencies, ambiguities, and errors.
- Could provide an excellent software maintenance tool if its quality were improved in accordance with the suggestions made in this report.

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

A. Purpose

Trident CCSMA has requested the Naval Postgraduate School (NPS) to evaluate the "Maintainability Enhancement for TCP/TSP Revision 6.0 Update .20" documents, subsequently referred to as 6.0/.20, with respect to its usability for maintaining Trident Command and Control System software.

B. Approach

It is understood that one of the governing documents for the production and use of Trident software is "Department of the Navy Tactical Digital Systems Documentation Standards," SECNAVINST 3560.1, 8 August 1974. Therefore, it was deemed appropriate to use this standard as one means of evaluating the subject documents. It was felt that, as a minimum, documentation used on the Trident project should meet the applicable sections of this standard. However, recognizing that this standard was issued many years ago and that the field of software engineering has evolved in the interim, additional criteria which reflect more modern software design and maintenance techniques were used in the evaluation.

The part of 3560.1 which appears to be most applicable to maintenance is the Program Description Document, pages 2-137 to 2-152. As stated in this document, its purpose, in part, is the following: "As a detailed compendium of the subprogram structure, the Program Description document

will serve as the essential instrument for subsequent use by operational, maintenance, and contractor personnel diagnosing troubles, making adaption changes, designing and implementing modifications to the system, and introducing or adding new subprogram functions to the completed program" (underlining added by the author).

Another means of evaluation was with respect to the publication "Guidelines for Documentation of Computer Programs and Automated Data Systems," National Bureau of Standards, Federal Information Processing Standards Publication 38 (FIPS PUB 38), February 15, 1976. As stated in FIPS PUB 38, its purpose is the following: "These guidelines provide a basis for determining the content and extent of documentation for computer programs and automated data systems. Software development phases and related document types are identified, several examples of documentation options are given, and content guidelines for ten document types are provided." Although, officially, this guideline is not applicable to Trident software because it was written to apply to ADP systems under the provisions of Public Law 89-306 (Brooks Bill), which excluded embedded computer systems, it is of technical interest because it is one of the few Federal Government software guidelines which covers program maintenance.

As stated in FIPS PUB 38, "The purpose of the Program Maintenance Manual is to provide the maintenance programmer with the information necessary to understand the programs, their operating environment, and their maintenance procedures." The Program Maintenance Manual is described on pages 45-47 of FIPS PUB 38.

It was also considered important to examine 6.0/.20 with respect to the applicable sections of MIL-STD 1679 (Navy), 1 December 1978,

the Navy's Military Standard for Weapon System Software Development. The applicable section of 1679 is primarily 5.11 Configuration Management, pages 23-24.

C. Scope

In order to ensure good software maintainability, it is necessary to use sound programming methodology and procedures, as well as provide good documentation. It is difficult to evaluate the quality of documentation and not also consider the quality of the product that has been documented, because good documentation of non-structured programs which contain machine language code, although of some benefit, will not result in good software maintainability, nor will good documentation of highly patched programs allow software to be easily maintained. In other words, if programs are inherently difficult to change and understand and may not have been designed with maintainability in mind, documentation may only make a marginal contribution to the improvement of maintainability. Thus, this project poses a dilemma because we have been asked to review and evaluate documentation for programs which are non-structured, contain significant amounts of machine language code, and are highly patched. It is understandable that this is the case, since the programs were designed prior to the availability of a mature structured programming methodology and high level languages for tactical system software development. In addition, although machine language patching is generally considered to be undesirable, for certain administrative and contractual reasons it is a prevalent practice in Navy embedded computer software development. The argument can be made that, because of these practices, good documentation is

even more important in this environment than it would be in those situations where the use of structured programming and high level languages provide a degree of self-documentation. Accordingly, the scope of this paper will be limited to evaluating the adequacy of 6.0/.20 for maintaining the TCP/TSP software, ignoring what is perhaps the more fundamental maintenance issue of the adequacy of the underlying software.

A major assumption of this study which affects its scope is that the 6.0/.20 documentation is to be evaluated independently of the program listings. It is noted that listings are not included in the version of 6.0/.20 dated 29 September 1979, although these were included in a prior version (undated). Quoting from Volume 1 of the version dated 29 September 1979, "The primary goal is to improve this software's maintainability by making the programs and their patches understandable and visible in a single simplified form," (underlining added by the author). The implication which has been derived based on the above statement and the fact that the listings are not included in the latest version, is that 6.0/.20 is to be used for maintenance purposes primarily on a stand-alone basis with listings utilized as a secondary source of information. This interpretation is critical with respect to some of the results obtained in this study, because certain deficiencies in 6.0/.20, which are noted later in this report, regarding such items as data design, tables and indexes, are not addressed by 6.0/.20 but are covered in the listings. If it was the intent to use the listings with 6.0/.20 in a coordinated fashion, it would be helpful to provide a detailed cross-referencing between the two. A method for accomplishing this cross-referencing is suggested

in a later section. The scope of this report is limited to considering 6.0/.20 as an independent tool for maintenance which does not rely extensively on the use of program listings. However, since the flowcharts are based on the program logic, as expressed in the listings, it was necessary to make extensive reference to the listings in this report in order to understand and evaluate 6.0/.20. In fact, a result of this analysis was the conclusion that the two mediums should be used as an integrated documentation package and not in isolation.

II. EVALUATION OF 6.0/.20

A. With Respect to SECNAVINST 3560.1, Program Description Document, Pages 2-137 to 2-152.

The following 3560.1 pages and sections are covered by 6.0/.20:

Page	Section	Title
2-141	1.	Scope
2-141	2.	Applicable Documents
2-142	3.	Requirements
2-142	3.1	Subprogram Detailed Description
2-143	3.2	Subprogram Flow Diagrams
2-148	3.6	Conditions for Initiation
2-149	3.8	Interface Description

The 3560.1 pages and sections which apparently are not covered by 6.0/.20 are identified below. It is possible that these sections are not applicable to certain volumes of 6.0/.20. However, the named missing sections were not found in any of the 6.0/.20 volumes for which copies were provided to NPS, so it is assumed that it was not intended to include these sections in 6.0/.20. A brief description of the intended contents of the missing sections as specified by 3560.1 is given:

Page	Section	Title	Contents
2-144	3.3	Subprogram Data Design	General summary description of the subprogram data base.
2-144	3.3.1	Tables	Detailed description of each table used in the subprogram data base: a. Table name. b. Purpose and type. c. Size and indexing procedure. d. Structure and bit layout.

2-145	3.3.2	Variables	Detailed description of each variable used in the subprogram data base: a. Variable name. b. Purpose. c. Structure and bit layout.
2-145	3.3.3	Flags	Detailed description of each flag used in the subprogram data base: a. Flag name. b. Purpose and status. c. Structure and bit layout.
2-145	3.3.4	Indexes	Technical description of each index used in the subprogram data base: a. Index name. b. Purpose.
2-146	3.3.5	Common Data Base Reference	Complete list of all references to local and common data base items and the location of each reference.
2-146	3.4	Input/Output Formats	Brief description and graphic (sample) representation of each input and output message, card format, tape format, etc. processed by the subprogram.
2-148	3.7	Subprogram Limitations	Summary of any known or anticipated limitations of the subprogram.
2-149	4.	Quality Assurance Provisions	Reference to all applicable test plans and procedures that have been used for verification of the subprogram. (6.0/.20 should reference the Trident Test Specification Requirements and Test Procedures which are described in Refs. 1 and 2.)

NOTE: It was not possible to determine whether Section 3.5 Required System Library Subroutines was covered by 6.0/.20 because it was not known whether library subroutines were used.

B. With Respect to FIPS PUB 38, Program Maintenance Manual , Pages 45-47

The following Program Maintenance Manual sections are covered by 6.0/.20

Section	Title
1.	General Information
1.1	Summary
1.2	Environment
1.3	References
2.	Program Descriptions
2.1	Program Identification
2.1.1	Problem and Solution Method
2.1.2	Input (description of)
2.1.3	Processing (logic, linkages, error handling)
2.1.4	Output (description of)
2.1.5	Interfaces
2.1.7	Run Description
3.	Operating Environment
3.2	Support Software
3.2.1	Operating System
3.2.2	Compiler, Assembler

The Program Maintenance Manual sections which apparently are not covered by 6.0/.20 are identified below. The caveats that were stated relative to 3560.1 also apply to this section.

Section	Title	Contents
2.1.2	Input	Layout, medium, codes, units of measurement, format, range of values or reference to a data element dictionary.
2.1.3	Processing	Variables, constants, restrictions, switches, flags.
2.1.4	Output	Layout, medium.
2.1.6	Tables	Identification, content, location, structure, purpose.
3.1	Hardware	Equipment required for operation of system and for each program.
3.3	Data Base	Description of data bases used or reference to a data element dictionary (codes, units of measurement, format, range of values).
4.	Maintenance Procedures	
4.1	Programming Conventions	Identification and descriptions.
4.2	Verification Procedures	Description of procedures to check the performance of programs, in general and following modification. Reference to test data and testing procedures. (6.0/.20 should reference the Trident Test Specification Requirements and Test Procedures which are described in Refs. 1 and 2).
4.3	Error Correction Procedures	Description of error conditions, sources and procedures for correction. (6.0/.20 should reference the Trident CCS Problem Reporting and Modification Systems which are described in Refs. 1 and 2.)
4.4	Special Maintenance Procedures	Description of special procedures which change with time or conditions (e.g., change of parameters, algorithms).
4.5	Listings and Flowcharts	Information about how to obtain copies of listings and flowcharts.

NOTE: It is possible that Section 3.3 Data Base is not applicable to any of the programs documented by 6.0/.20.

C. With Respect to MIL-STD 1679 (Navy), Configuration Management, Pages 23-24

The following configuration management sections of 1679 are covered by 6.0/.20:

Section	Title
5.11	Configuration Management
5.11a	Positive identification of all program components
5.11.1	Configuration Identification
5.11.1.1	Baselines
5.11.1.2	Documentation Identification
5.11.1.2a	Component
	b. Purpose
	c. Baseline
	d. Serial, edition and change status

The sections which apparently are not covered by 6.0/.20 are identified below. The caveats that were stated relative to 3560.1 also apply to this section.

Section	Title
5.11b	Treatment of proposed changes to components under configuration control.
5.11c	Implementation of approved changes and dissemination of corrected documentation and program changes.
5.11d	Recording of status of all proposed changes.
5.11e	Verification of change control, identification and status account of documentation and program materials.

5.11.2	Configuration Control	Procedures for formal control of all documents, program materials and support library shall be established.
5.11.2.1	Software Changes	Proposed changes to software which is under configuration control shall be submitted to the appropriate software configuration control boards.
5.11.2.2	Documentation Changes	Procedures for controlling preparation and dissemination of changes to documentation shall be developed.
5.11.2.3	Software Configuration Control Boards	Each baseline plus approved changes from those baselines shall be under the formal control of a responsible board.
5.11.3	Configuration Status Accounting	Procedures to enable the generation of periodic status reports on all components under configuration management shall be established.

With respect to the above sections, 6.0/.20 should reference the Trident CCS Problem Reporting and Modification Systems and the Configuration Management System which are described in Refs. 1 and 2.

III. OTHER COMMENTS

The following comments pertain to 6.0/.20 Volume 2, using it as an example.

A. Functional Description, on Pages 3-1 to 3-3

1. The discussion would be more meaningful if it were keyed to the hierarchical structure diagrams and to the flowcharts. For example, definitions and descriptions of pertinent interrupts should be provided, including important symbolic addresses which are utilized. This information and the interrupt numbers should be related to the diagrams.

2. Sub-headings for the various sections, such as "Interrupt Handling," would make the text more readable.

3. Some typos were observed which affect understandability. For example, the fifth line in the second paragraph on page 3-3.

4. Although this comment does not concern quality of documentation, it was noted on page 3-2 that the control memory test for all zeros and all ones should be preceded by setting the relevant portions of main memory to non-zero and non-one data, respectively, prior to the transfer of control memory to main memory.

B. Hierarchical Structure Diagrams

1. Hierarchical structure diagrams and flowchart symbols should be defined at the beginning of each volume. It is not clear that these diagrams strictly adhere to ANSI standards (see Reference 3).

2. A consistent hierarchical structure box numbering system should be utilized which would indicate at a glance two important pieces of information: the function (e.g., "Periodic Entry") to which the routine belongs, and the level of the routine within the function. This scheme is shown on the accompanying hierarchical structure diagrams, which were reproduced from Volume 2 (pages 4-4 to 4-8). The left digit is function number, the middle digit is level number and the right digit is routine number for a given level and function. Level numbers start at "1" and increase from top to bottom; routine numbers start at "1" and increase from left to right. These numbers should be referenced to the pertinent flowcharts, as shown on the accompanying diagrams (pages 4-9 to 4-12 of Volume 2). As a means of tying together hierarchical structure diagrams, flowcharts and listings, the identification numbers could be appended to the listings as shown on the reproduced CMS-2 Assembler listing (page 6 of listing), which is attached. Two columns are utilized: one is the "At" column corresponding to lines with labels; the other is the "To" column corresponding to lines with transfer of control. Perhaps these identifiers could be punched and printed in formatted columns as part of the "Comments" field. A further help would be to sort source statements by the "At" column and to indent based on the middle digit. This would provided a structured listing of an entire function in contiguous locations.

3. Although it is not a fault of the flowcharting process, it was observed that there is a similarity of labels (e.g., CTPRE and CTPER). This could lead to error in software maintenance.

C. Flowcharts

1. The entry to a flowchart page should be annotated with the flowchart page numbers which are associated with the source(s) of the transfer of control and the exit(s) from a flowchart page should indicate the page number(s) which are associated with the destination(s) of the transfer of control. This is shown on the attached pages 4-9 to 4-12 of Volume 2.

2. There is no loop back to CTPER1 on page 4-9 of the flowcharts, as indicated by the JBNZ instruction at line 223 on page 6 of the listing. Instead the box at the bottom of page 4-9 reads: "Repeat Data Pattern Test Using 'IWC' Control Word." Similarly there is no loop back to CTPER2 on page 4-10 nor loop back to CTPER3 on page 4-11, as shown by line 230 and 238, respectively, on the listing. This method of presentation seems to mask an important characteristic of the program logic.

3. There seem to be discrepancies between flowcharts and listings. For example, the second box from the bottom of page 4-11 figure 4.3 refers to IWC. Page 6, lines 243 and 244 refer to ICW. The box in the flowchart also refers to "Set Up Class IV," while line 243 on the listing refers to Class II.

D. Interpretation of Hierarchical Structure Diagrams

1. Using Volume 2 as an example, it appears that the hierarchical structure diagrams are not totally accurate in portraying program logic. For example, the following discrepancies were noted between hierarchical structure and the listings:

a. With respect to page 4-5, figure 4.2, CTPER is shown superior to all other routines on this chart, yet an analysis of the listing reveals that CTPER only happens to be the first label in this series of code and its only paths to other labels are to CTPER1 and CTPERROR. The latter reference brings to light another discrepancy. CTPER does have a conditional branch to CTPERROR in the listing (line 219), but according to figure 4.2, there is no path between these routines. Wtih respect to figure 4.2, the listings indicate the following access paths among routines:

- CTPER accesses CTPER1 and CTPERROR.
- CTPER1 accesses CTPER2 and CTPERROR.
- CTPER2 accesses CTPER3 and CTPERROR.
- CTPER3 accesses CTRTN and CTPERROR.

Thus, a more accurate picture of this logic is shown in the diagram labeled "Revised Figure 4.2 CT Hierarchical Structure (2 of 5)." It should be noted that in this diagram the horizontal lines indicate paths between adjacent code segments that are in the same module and vertical lines indicate paths involving transfer of control. Also, the arrows, from left to right and from top to bottom, indicate the general direction of control flow. In large measure the "routines" which have been shown as hierarchical structures boxes in Volume 2 are simply labels in a segment of code. This has been pointed out in Volume 2 on page 4-3. The difficulty in constructing the hierarchical structure from program listings is that by definition, the diagrams are supposed to indicate hierarchy, i.e., superior-subordinate relationships, and programs designed using a top-down approach. Since the

programs were not written this way, the imposition of a hierarchical structure on a coding format that is inherently non-structured will lead to incompatibilities between diagrams and listings, unless great care is exercised in performing the translation.

b. Pages 4-7 and 4-8, figure 4.2, show CTKLAS2 as having access to CTKLASY. The listing indicates that this actually occurs via CTKLIPI (lines 314 and 342), which is not listed as a routine in figure 4.1, page 4-2 of volume 2. CTKLIPI also has a path to CTARITH via CTKL2XIT at line 349. Page 4-8 also shows no path between CTKAS2I and CTKLASY*. However, the listing shows this path to exist. This condition was verified by consulting the CMS-2 Assembler List Cross Reference Table. One of these references to CTKLASY occurs from the same routine.

- Pages 4-7 and 4-8 show no path between CTKLAS2 and CTKLAS2Z. However, line 335 on the listing shows that this label is contained within routine CTKLAS2.

- Page 4-8 shows no path between CTKLASY and CTKLAS2J. A check of the List Cross Reference Table revealed that this path does exist; this reference to CTKLAS2J occurs at line 430. However, this path is used only when a 4 stop condition does not exist.

- Taking the above difference into account, page 4-8 has been redrawn and is labeled as "Revised Figure 4.2 CT Hierarchical Structure (5 of 5)." Again, the procedure was to use horizontal arrows (going into side of box) to indicate adjacent code segment relationships (e.g., between CTKLAS2 and CTKLAS2Z and between CTKLAS2I and CTKLAS2J) and vertical arrows (going into top of box) to show transfer of control.

---

*At least it is not unambiguous as to whether there is a path between CTKLAS2 and CTKLASY or between CTKLAS2I adn CTKLASY, or both.

- Note: The revised hierarchical structure diagrams would obviously have different numbers for some boxes than those used in Section B.2. The latter was based on the given hierarchical structure diagrams as shown in Volume 2.

c. It was not clear in what sense lines with arrows and those without arrows were used in the hierarchical structure diagrams of Volume 2. If the use of arrows was to show transfer of control and the absence of arrows to tie together routines of the same module, the method would be inconsistent because there are no arrows on the lines which connect CTKLAS2 to CTKLAS2(A-I) in figure 4.2 of Volume 2.

E. Inter-Module Message Tables

These tables, such as the one on page 4-34, figure 4.4, Volume 2, should indicate the page number of the flowchart of the referenced procedure (routine).

F. Configurations

The hardware and configuration to which 6.0/.20 applies should be defined in each volume.

G. Patch Listings

Patch listings in Volume 1 should have column headings.

H. Audit Comments

Although we do not agree with the comment on page A-1, Volume 2 that, ". . . the module is readily understandable even though it is non-modular," we do feel that this is a valuable part of maintenance documentation. Perhaps this section could be expanded.

MESSAGE ENTRY

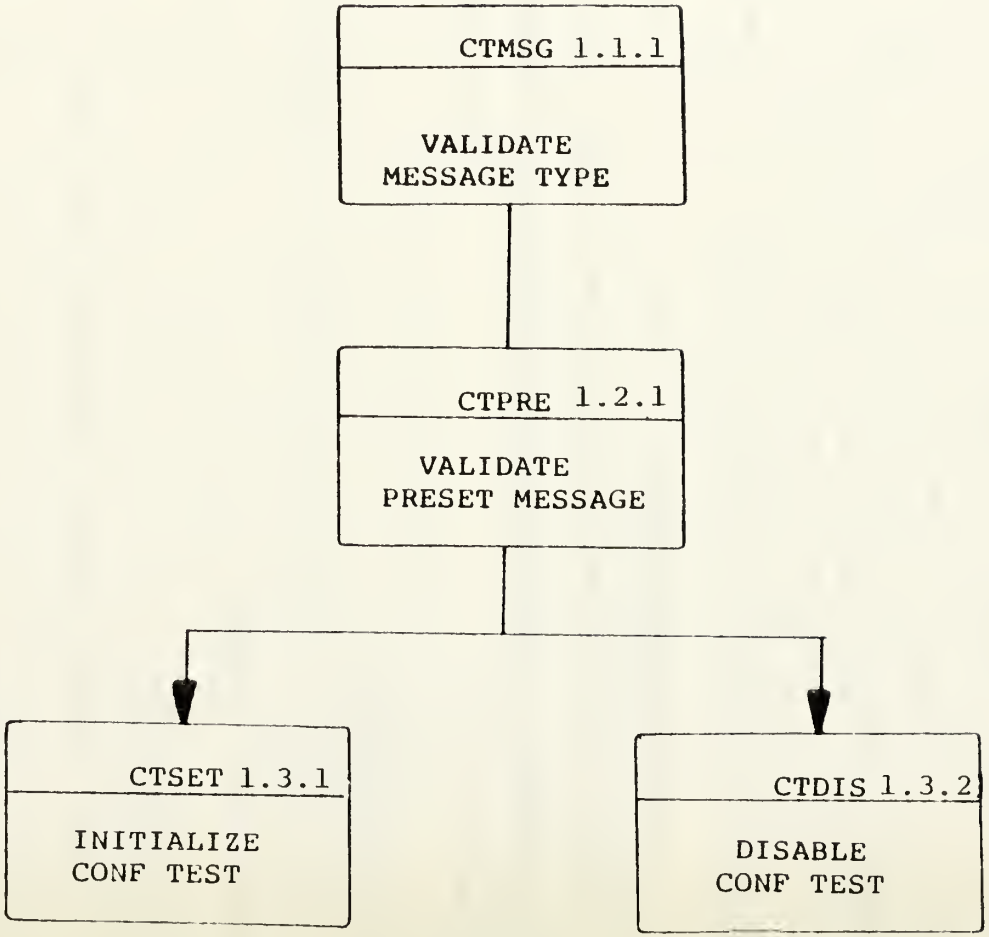


FIGURE 4.2 CT Hierarchical Structure (1 of 5)

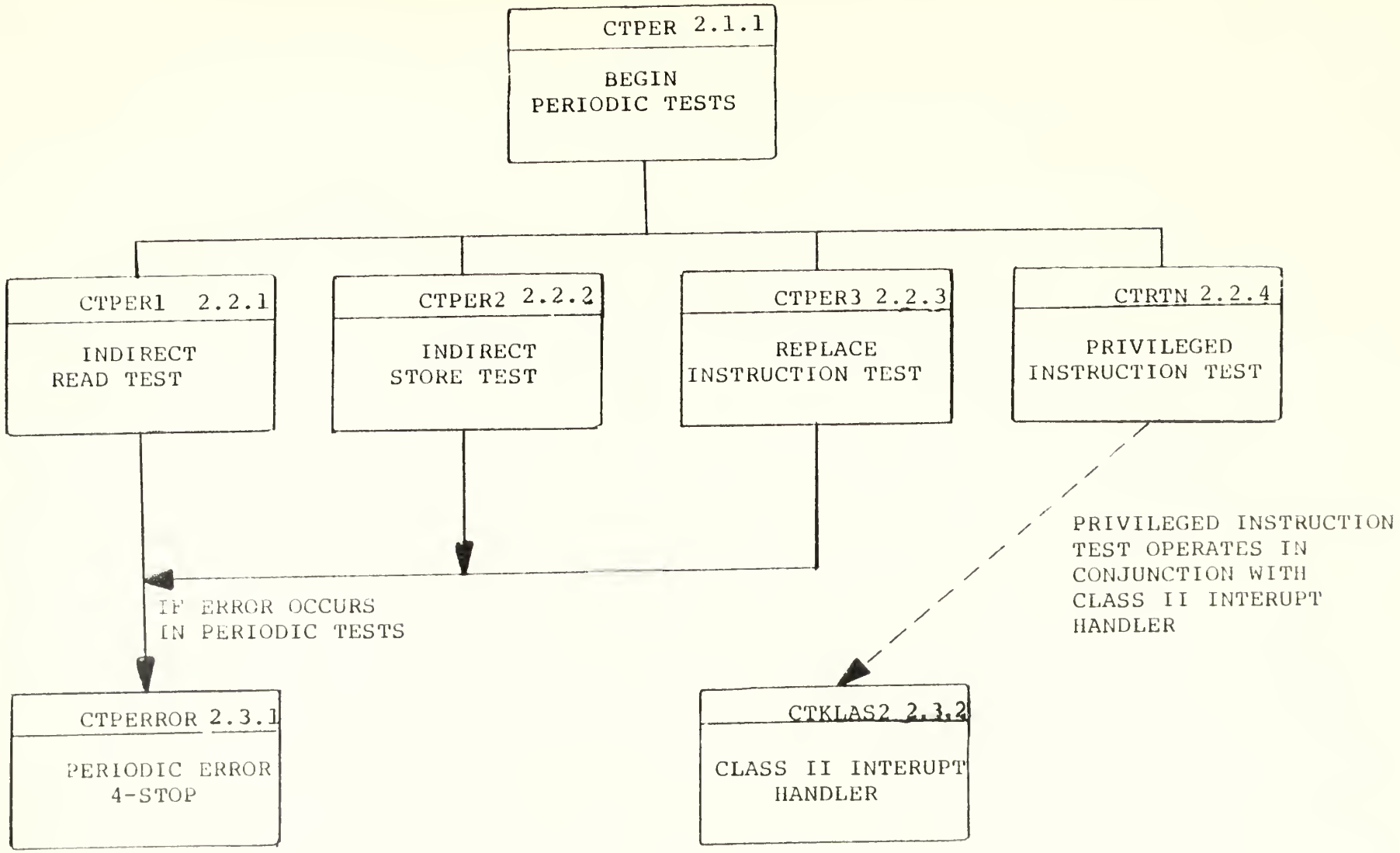


FIGURE 4.2 CT Hierarchical Structure (2 of 5)
Page 4-5

DEFERRED ENTRY

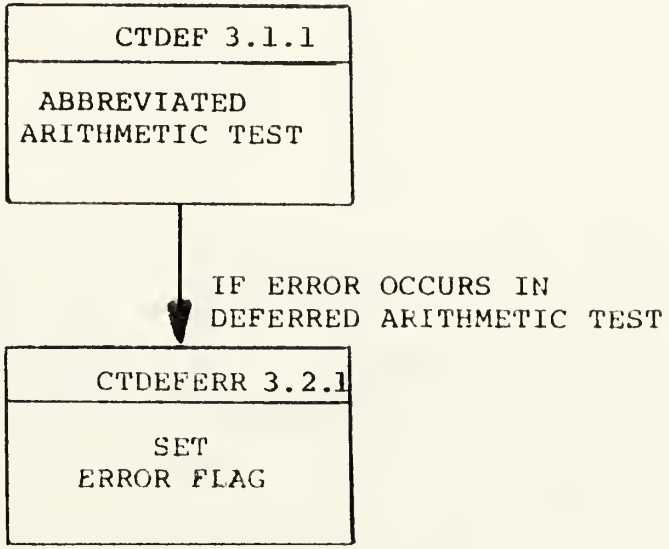


FIGURE 4.2 CT Hierarchical Structure (3 of 5)
Page 4-6

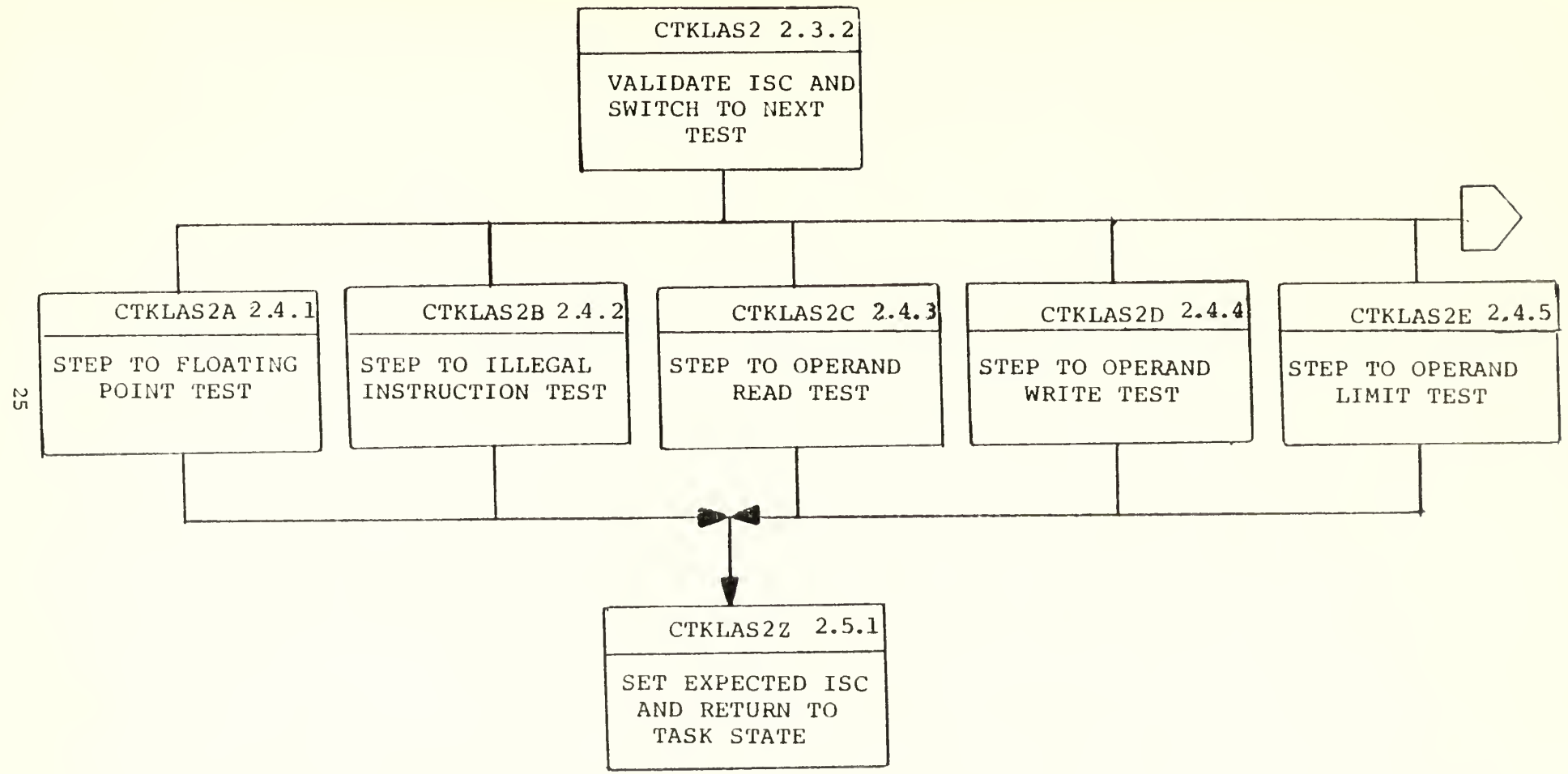


FIGURE 4.2 CT Hierarchical Structure (4 of 5)

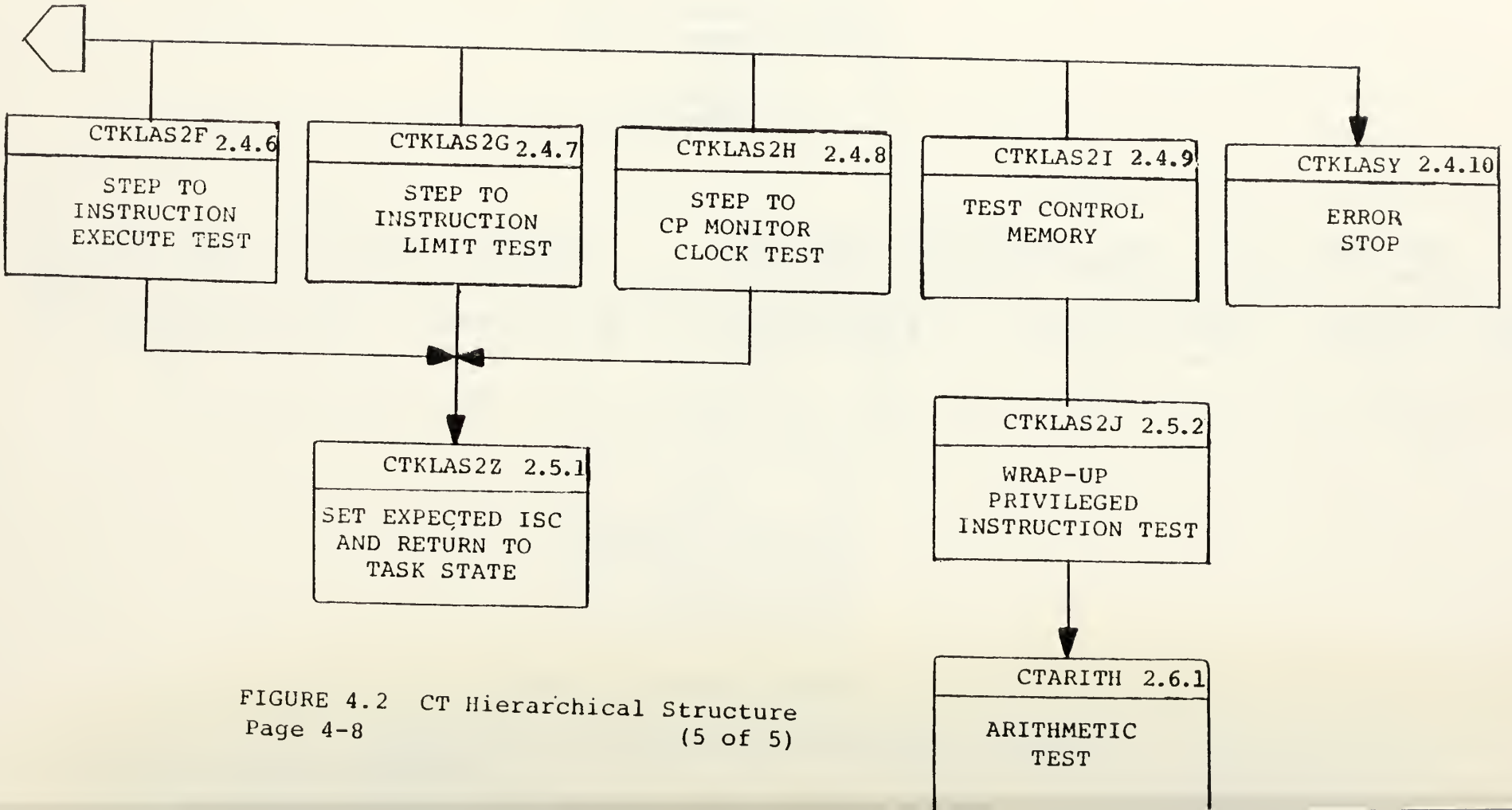


FIGURE 4.2 CT Hierarchical Structure (5 of 5)
Page 4-8

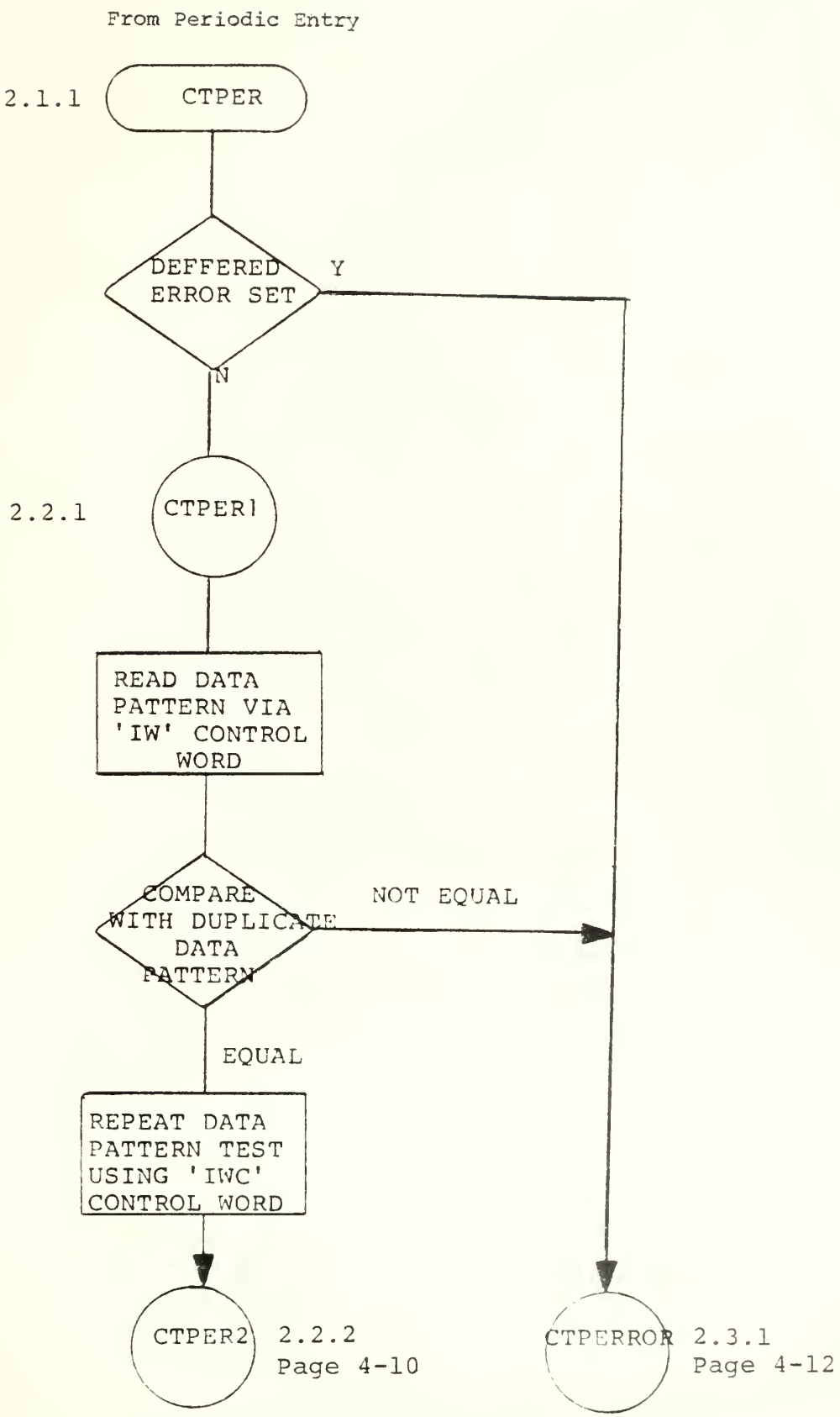
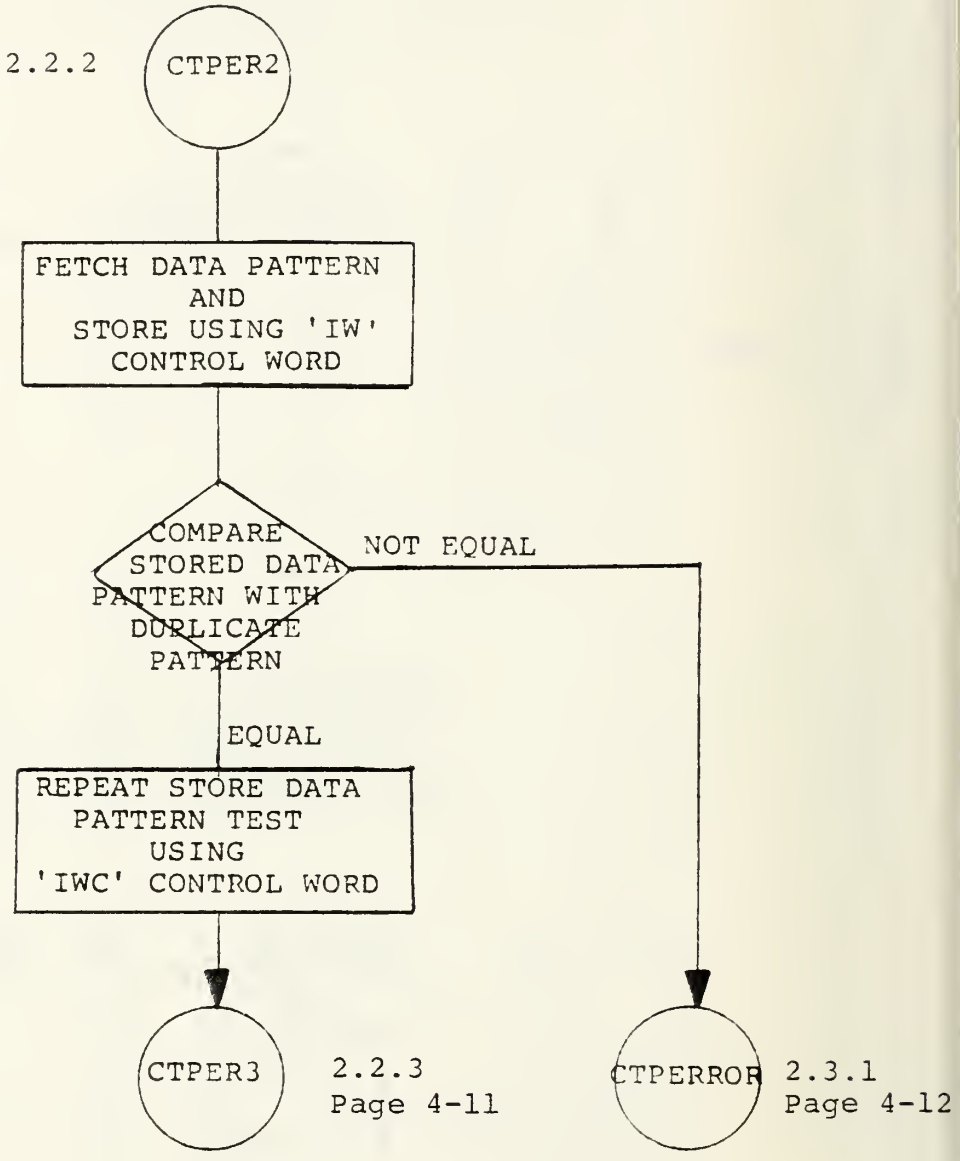


FIGURE 4.3 CT Flowcharts (1 of 25)
Page 4-9

From Page 4-9



FIGUPE 4.3 CT Flowcharts (2 of 25)
Page 4-10

From Page 4-10

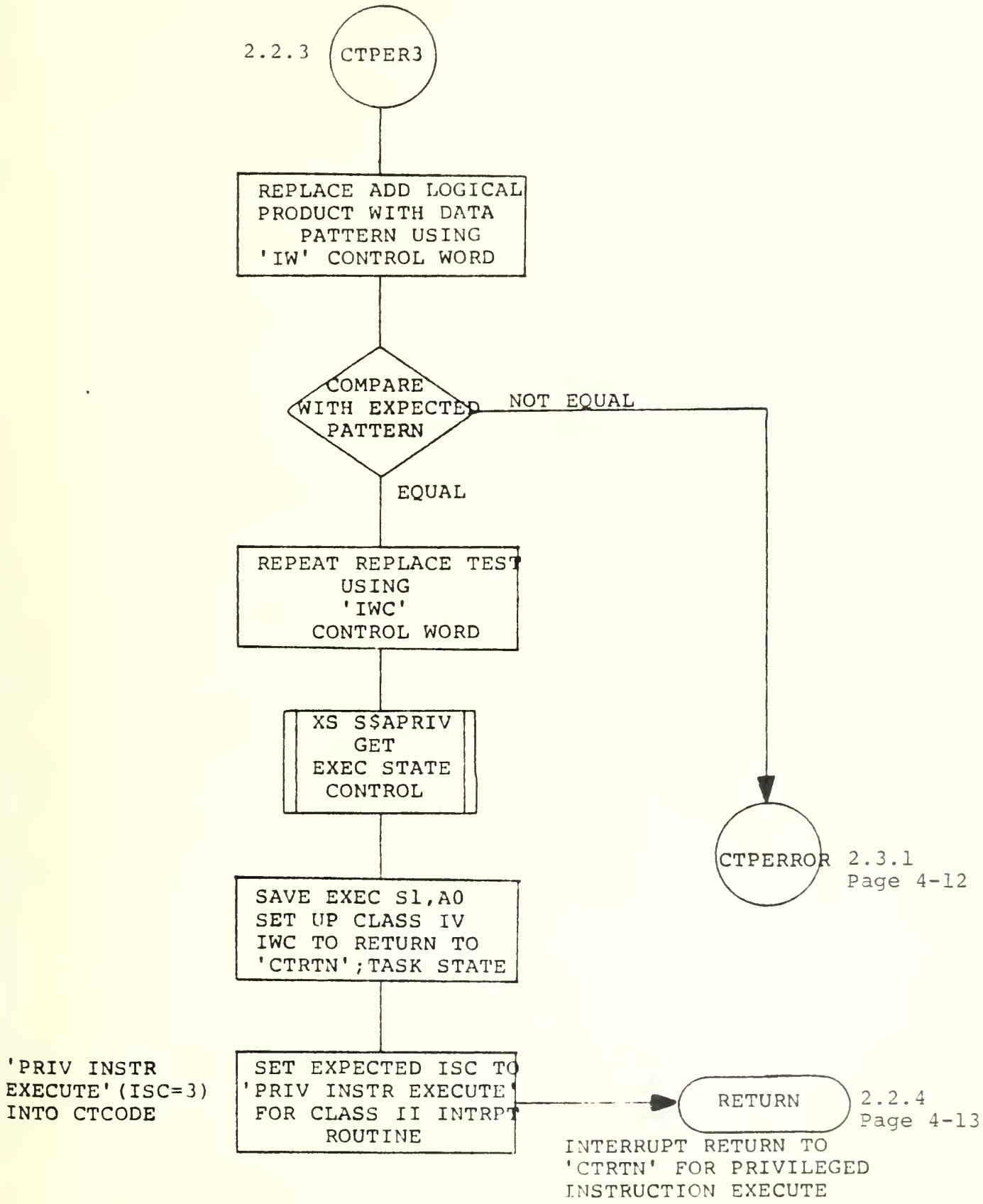


FIGURE 4.3 CT Flowcharts (3 of 25)
Page 4-11

From Pages 4-9,10,11

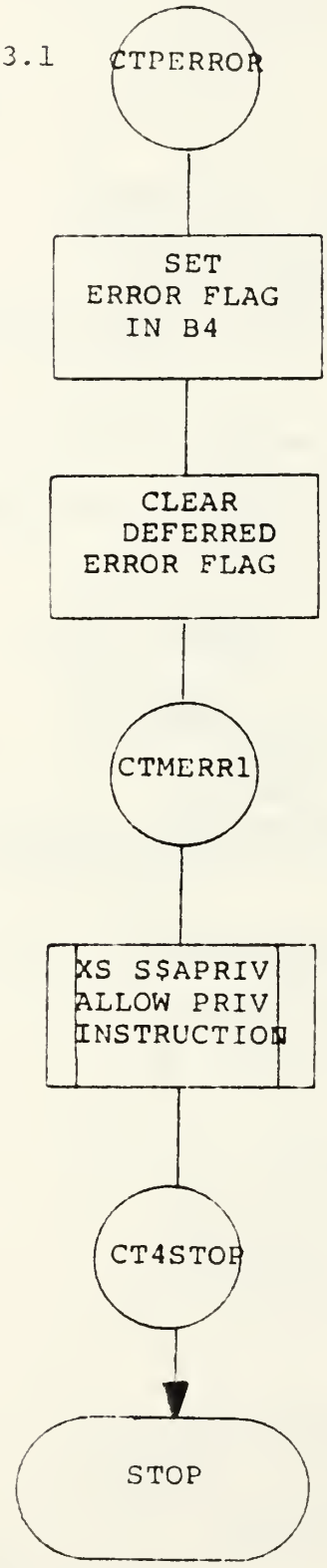


FIGURE 4.3 CT Flowcharts (4 of 25)
Page 4-12

```
 ID  S N AC  ADDR  F  A K B I  SY     LABEL    OP CODE    OPERAND                  COMMENTS                          SEQUENCE
 00191        000137 23 0 3 0 0 0 000521           SB         B0,CTERRFLAG,X3     . CLEAR ERROR FLAG                CTM1003/1
 00192        000040 07 0 0 0 0 0 000004           XS         S$EXIT              . EXIT                            CTM1003B
 00193        000041 07 0 0 0 0 0 000104  CTDIS    XS         S$DELPER            . DELETE PERIODIC                 CTM10040
 00194        000042 07 0 0 0 0 0 000110           XS         S$DELDEF            . DELETE DEFERRED                 CTM10041
 00195        000043 10 0 0 0 0 0 0 00744          LA         A0,CTERM,GE,A0,B0,S0 .                                E1568Z
 00196        000044 10 1 0 0 0 0 000004           LA         A1,4                .                                 E158RZ
 00197        000045 07 0 0 0 0 0 000203           XS         S$DMES              .                                 E158RZ
 00198        000046 07 0 0 0 0 0 000004           XS         S*EXIT              . EXIT                            CTM1C042
 00199        000047 20 4 0 0 0 0 000000  CTHERR   LB         E4,0                . MESSAGE ENTRY FLAG              CTM10087
 00200        000050 07 0 0 0 0 0 000425  CTHERR1  XS         S$APRIV             . ENABLE PRIVELEGED INST.         CTM10091
 00201        000051 53 4 3 0 0 0 0 000051 CT4STOP  JSC        4,CT4STOP           . 4 STOP                          CTM10092
 00202                                    . ********** PERIODIC ENTRY                                  **********  CTM10104
 00203        000052 20 7 0 0 0 0 000001  CTPER     LB         B7,1                . INDIRECT ADDRESSING TEST        CTM10105   2.1.1
 00217                                               ENDSET     BRCONDE, CTERBALD   . C-SWITCH END FIXED S U
 00218        000053 42 02 0 0 0 000521            AC         2,CTERFLAG          . CHECK DEFERRED ERROR            CTM1010S1
→00219        000054 53 0 1 0 0 0 000337           JNE        CTPERROR            . GO TO ERROR MESSAGE             CTM10102                2.3.1
→00220        000055 10 0 3 7 1 000475  CTPER1    LA         A0,*CTRDIR1,X3,B7   . CHECK READ CLASS             CTM10106   2.2.1
 00221        000056 44 0 3 7 0 000477             C          A0,CTC1,X3,B7       . IS IT CORRECT                   CTM10107
 00222        000057 53 0 1 0 0 0 000337           JNE        CTPERROR            . IF NOT GO TO ERROR              CTM10108                2.3.1
→00223        000060 52 7 1 0 0 0 000055           JBNZ       B7,CTPER1           . TEST BOTH IN AND INC            CTM10109                2.2.1
 00224        000061 20 7 0 0 0 0 000001           LB         B7,1                . CHECK STORE CLASS               CTM10110
 00225        000062 10 0 3 7 0 000473  CTPER2    LA         A0,CT2SPAT,X3,B7    .                                 CTM10111   2.2.2
 00226        000063 24 0 3 7 1 000503             SA         A0,*CTIDRV1,X3,B7   . TRY IT                          CTM10112
 00227        000064 10 0 3 7 0 000505             LA         A0,CTV1,X3,B7       . FETCH WHOLE WORD                CTM10113
 00228        000065 44 0 3 7 0 000501           C            A0,CTC2,X3,B7       . CHECK IT                        CTM10114
 00229        000066 53 0 1 0 0 0 000337           JNE        CTPERROR            . IS IT CORRECT                   CTM10115                2.3.1
→00230        000067 52 7 1 0 0 0 000062           JBNZ       B7,CTPER2           . GET BOTH                        CTM10116                2.2.2
 00231        000070 71 7 7 7 6                    BAN        A7,A7               . CLEAR MASK                      CTM10117
 00232        000071 20 7 0 0 0 0 000001           LB         B7,1                . TEST REPLACE CLASS              CTM10118
 00233        000072 10 0 3 7 0 000473  CTPER3    LA         A0,CT2SPAT,X3,B7    .                                 CTM10119   2.2.3
 00234        000073 03 7 7 7 1 000503             XALP       A7,*CTIDRV1,B7      . TRY IT                          CTM10120
 00235        000074 10 0 3 7 0 000505             LA         A0,CTV1,X3,B7       . CHECK IT                        CTM10121
 00236        000075 44 0 3 7 0 000501             C          A0,CTC2,X3,B7       .                                 CTM10122
 00237        000076 53 0 1 0 0 0 000337           JNE        CTPERROR            . IS IT CORRECT                   CTM10123                2.3.1
→00238        000077 52 7 1 0 0 0 000072           JBNZ       B7,CTPER3           . TRY BOTH                        CTM10124                2.2.3
 00239                                    . **** PRIVILEGED INSTRUCTION TEST                                     CTM10125
 00240        000100 07 0 0 0 0 0 000425           XS         S$APRIV             . GET EXEC STATE CONTROL          CTM10126
 00241        000101 54 70 0 0 0 000510            LCI        070,CTASR1          . SET ALL INTERRUPT LOCKOUTS      CTM10127
 00242        000102 57 00 0 0 0 000514            SCI        0,CTINTEM3          . SAVE EXEC A0                    CTM10128
→00243        000103 57 44 0 0 0 000512            SCI        044,CTINTEM1        . SAVE CLASS II ICW               CTM10129
→00244        000104 55 44 0 0 0 000516            LCI        044,CTINTEN1        . SET UP ICW                      CTM10130
 00245        000105 57 21 0 0 0 000513            SCI        021,CTINTEM2        . SAVE EXEC S1                    CTM10131
 00246        000106 60 21 0 0                     HSCT       021,A0              . SET UP EXEC S1                  CTM10132
 00247        000106 61 21 0 1                     HSCI       021,A0              .                                 CTM10133
 00248        000107 55 55 0 0 0 000511            LCI        055,CTASR2          . PREPARE TO GO TO TASK           CTM10134
 00249        000110 55 57 0 0 0 000515            LCI        057,CTPSTA          .                                 CTM10135
 00250        000111 23 0 3 0 0 0 000524           SB         B0,CTCOUNT1,X3      . CLEAR INTERRUPT COUNTER         CTM10136
 00251        000112 10 0 0 0 0 0 000003           LA         A0,3                .                                 CTM10137
 00252        000113 24 0 3 0 0 0 000525           SA         A0,CTCODE,X3        .                                 CTM10138
 00253        000114 07 0 5 0 0 0 0 00001          IR                             . TO TASK STATE                   CTM10139
 00254        000115 07 0 2 0 0 0 000000  CTRIP    PLI        0                   . EXECUTE PRIVILEGED INSTRUCT     CTM10140   2.2.4
 00255        000116 07 0 3 0 0 0 000000           LIN        0                   .                                 CTM10141
```

Flow Chart I.D. A7 TO

```
ID  LOC  ADDR  F  A  K  B  I  SY     LABEL    OP CODE   OPERAND                  COMMENTS                          SEQUENCE
00256        000117 07 0 4 0 0 000000          IO        0                        .                                 CTM10192
00257        000120 07 0 5 0 0 0 000000        IR        0                        .                                 CTM10193
00258        000121 53 4 2 0 0 0 000000        RJSC      4                        .                                 CTM10194
00259        000122 53 4 3 0 0 0 000000        JSC       4                        .                                 CTM10195
00260        000123 54 20 0 0 000000           LCT       020                      .                                 CTM10196
00261        000124 54 60 0 0 000000           LCT       060                      .                                 CTM10197
00262        000125 54 70 0 0 000000           LCT       070                      .                                 CTM10198
00263        000126 55 00 0 0 000000           LCI       0                        .                                 CTM10199
00264        000127 56 20 0 0 000000           SCT       020                      .                                 CTM10150
00265        000130 56 60 0 0 000000           SCT       060                      .                                 CTM10151
00266        000131 56 70 0 0 000000           SCT       070                      .                                 CTM10152
00267        000132 60 20 0 0                  HSCT      020                      .                                 CTM10154
00268        000132 74 0 3 0 0                 HNO                                .                                 CTM10153
00269        000133 60 60 0 0                  HSCT      060                      .                                 CTM10156
00270        000133 74 0 3 0 0                 HNO                                .                                 CTM10155
00271        000134 60 70 0 0                  HSCT      070                      .                                 CTM10158
00272        000134 74 0 3 0 0                 HNO                                .                                 CTM10157
00273        000135 60 00 0 1                  HSCI      A0                       .                                 CTM10160
00274        000135 74 0 3 0 0                 HNO                                .                                 CTM10159
00275        000136 61 20 0 0                  HLCT      020                      .                                 CTM10162
00276        000136 74 0 3 0 0                 HNO                                .                                 CTM10161
00277        000137 61 60 0 0                  HLCT      060                      .                                 CTM10164
00278        000137 74 0 3 0 0                 HNO                                .                                 CTM10163
00279        000140 61 70 0 0                  HLCT      070                      .                                 CTM10166
00280        000140 74 0 3 0 0                 HNO                                .                                 CTM10165
00281        000141 61 00 0 1                  HLCI      A0                       .                                 CTM10168
00282        000141 74 0 3 0 0                 HNO                                .                                 CTM10167
00283        000142 77 0 0 0 0                 HSIM      0                        .                                 CTM10170
00284        000142 74 0 3 0 0                 HNO                                .                                 CTM10169
00285        000143 77 0 4 0 0                 HPI                                .                                 CTM10172
00286        000143 74 0 3 0 0                 HNO                                .                                 CTM10171
00287        000144 77 0 5 0 0                 HAI                                .                                 CTM10174
00288        000144 74 0 3 0 0                 HNO                                .                                 CTM10173
00289        000145 77 0 6 0 0                 HALT                               .                                 CTM10176
00290        000145 74 0 3 0 0                 HNO                                .                                 CTM10175
00291        000146 77 0 6 0 1                 HMFI                               .                                 CTM10178
00292        000146 74 0 3 0 0                 HNO                                .                                 CTM10177
00293        000147 07 1 0 0 0 000000          IPI       0                        .                                 CTM10179
00294        000150 07 0 1 0 0 000000          AEI       0                        .                                 CTM10180
00295        000151 05 0 0 0 0 0 000517        DL        A0,CTOPES                . GENERATE FLOATING               CTM10181
00296        000152 06 0 0 0 0 0 000517        FA        A0,CTOPES                . POINT ERROR                     CTM10182
00297        000153 000000000000               +         0                        . GENERATE ILLEGAL INSTRUCTION    CTM10183
00298        000154 10 0 3 0 0 4 00154 CTOP1   L1        A0,CTOP1,K3,,SCTTRAN4          . OPERAND READ ERR          CTM10184
00299        000155 20 0 3 0 0 0 0 00155 CTOP2 SA        A0,CTOP2,K3,,SCTTRAN0          . OPERAND WRITE ERR         CTM10185
00300        000156 24 0 3 0 0 5 00156 CTOP3   SA        A0,CTOP3,K3,,SCTTRAN5          . OPERAND LIMIT ERR         CTM10186
00301        000157 53 0 3 0 0 0 6 00140       J         B+1, , ,SCTTRAN6               .                           CTM10187
00302        000160 20 0 0 0 0 4 000000 CTOP4  LB        A0,0                           . INSTRUCTION EXECUTE ERR   CTM10188
00303        000161 53 0 3 0 0 0 5 00142       J         B+1, , ,SCTTRAN5               .                           CTM10189
00304        000162 20 0 0 0 0 0 000000 CTOP5  LB        A0,0                           . INSTRUCTION LIMIT ERR     CTM10190
00305        000163 53 0 3 0 0 0 000143 CTOP6  J         CTOP6                    . WAIT FOR INTERRUPT              CTM10192
00306                                          . *** INTERRUPT ROUTINE FOR CLASS 2 ERRORS                          CTM10193
00307        000164 54 70 0 0 000510 CTKLAS2   LCI       C70,CTASRI               . TO TASK REGISTERS               CTM10194
```

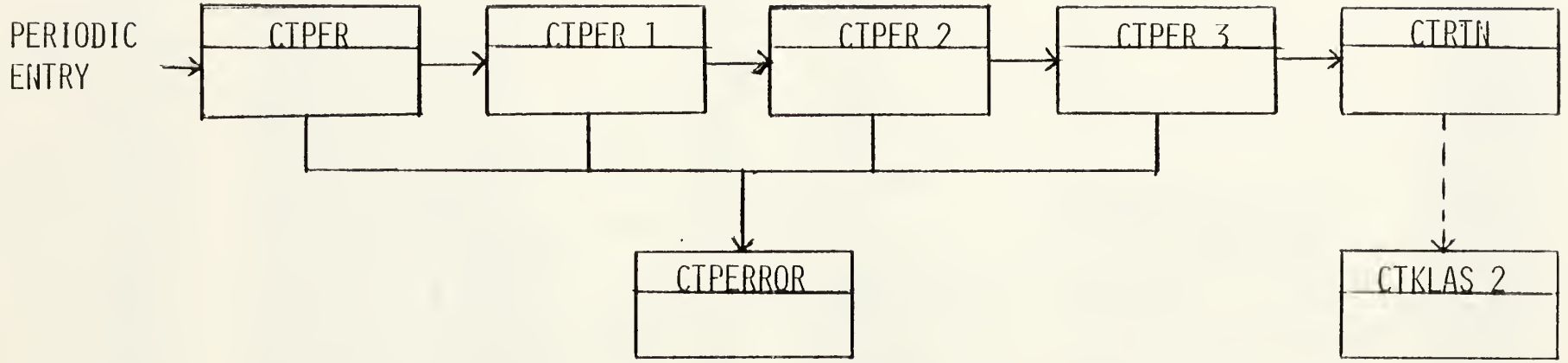
```
ID  FLR AC  ADDR   F  A K E I    ST      LABEL    OP CODE   OPERAND          COMMENTS                         SEQUENCE

00308       000165 20 46 0 1                      HSCI      D46,A0           . CHECK STATUS CODE              CTM10195
00309       000166 20 0 0 0 0 000000              LB        B0,0             .                                CTM10196
00310       000167 35 1 3 0 0 000524              RI        A1,CTCOUNT1,K3   . INCREMENT TEST COUNT           CTM10197
00311       000170 44 0 3 0 0 000525              C         A0,CTCODE,K3     . IS STATUS CODE CORRECT         CTM10198
00312                                    . .
00313                                    . PPPPPPPPPPPPPPPPPPPPPPPP..T1-H007--01..PPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
00314       000171 53 0 1 0 0 000221              JNE       CTKLIPI          . NO, CHK IPI                    P
00315                                    . PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
00316                                    .
00317       000172 44 1 0 0 0 000034              C         A1,28            . ALL PRIVILEGED INSTRUCTIONS    CTM10200
00318       000173 53 1 1 0 0 0 000227            JE        CTKLAS2A         .                                CTM10201
00319       000174 44 1 0 0 0 000035              C         A1,29            . TRIED FLOATING POINT           CTM10202
00320       000175 53 1 1 0 0 0 000231            JE        CTKLAS2B         .                                CTM10203
00321       000176 44 1 0 0 0 000036              C         A1,30            . TRIED ILLEGAL INSTRUCTION      CTM10204
00322       000177 53 1 1 0 0 0 000233            JE        CTKLAS2C         .                                CTM10205
00323       000200 44 1 0 0 0 000037              C         A1,31            . TRIED OPERAND READ             CTM10206
00324       000201 53 1 1 0 0 0 000235            JE        CTKLAS2D         .                                CTM10207
00325       000202 44 1 0 0 0 000040              C         A1,32            . TRIED OPERAND WRITE            CTM10208
00326       000203 53 1 1 0 0 0 000237            JE        CTKLAS2E         .                                CTM10209
00327       000204 44 1 0 0 0 000041              C         A1,33            . TRIED OPERAND LIMIT            CTM10210
00328       000205 53 1 1 0 0 0 000241            JE        CTKLAS2F         .                                CTM10211
00329       000206 44 1 0 0 0 000042              C         A1,34            . TRIED INSTRUCTION EXECUTE      CTM10212
00330       000207 53 1 1 0 0 0 000243            JE        CTKLAS2G         .                                CTM10213
00331       000210 44 1 0 0 0 000043              C         A1,35            . TRIED INSTRUCTION LIMIT        CTM10214
00332       000211 53 1 1 0 0 0 000246            JE        CTKLAS2H         .                                CTM10215
00333       000212 44 1 0 0 0 000044              C         A1,36            . TRIED CP MONITOR CLOCK         CTM10216
00334       000213 53 1 1 0 0 0 000252            JE        CTKLAS2I         .                                CTM10217
00335       000214 24 0 3 0 0 000525     CTKLAS2Z SA        A0,CTCODE,K3     . SAVE NEXT EXPECTED STATUS CC   CTM10218
00336       000215 60 47 0 1                      HSCI      D47,A0           . UPDATE P-STORE                 CTM10219
00337       000216 14 0 0 0 0 000001              AA        A0,1             .                                CTM10220
00338       000217 61 47 0 1                      HLCI      H47,A0           .                                CTM10221
00339       000220 07 0 5 0 0 0 000000            IR                         . TO NEXT TEST                   CTM10222
00340                                    . .
00341                                    . PPPPPPPPPPPPPPPPPPPPPPPP..T1-H007 -01..PPPPPPPPPPPPPPPPPPPPPPPPPPPPP
00342       000221 51 0 3 0 0 0 000335   CTKLIPI  JNZ       A0,CTKLASY       . ERROR IF NOT IPI               P
00343                                    . . LEGITIMATE IPI RECEIVED FROM OTHER PROCESSOR DURING THIS TEST    P
00344                                    . . - REGENERATE THE IPI TO PREVENT LOSS                             P
00345       000222 07 0 0 0 0 000425              XS        S$APRIV          . ALLOW PRIV INSTR               P
00346       000223 07 0 0 0 0 000416              XS        S$CPNUM          . GET THIS PROCESSOR NUMBER      P
00347       000224 61 11 0 0                      HLCT      011,A0           . FOR INDEX                      P
00348       000225 02 0 2 1 0 000471              XR        CTGENIPI,B1      . GEN IPI FOR THIS PROCESSOR     P
00349       000226 53 0 3 0 0 0 000320            J         CTKL2ZIT         . EXIT CL II INTERRUPT TEST      P
00350                                    . PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
00351                                    . .
00352       000227 10 0 0 0 0 000001     CTKLAS2A LA        A0,1             . FLOATING POINT STATUS CODE     CTM10223
00353       000230 53 0 3 0 0 0 000214            J         CTKLAS2Z         .                                CTM10224
00354       000231 10 0 0 0 0 000002     CTKLAS2B LA        A0,2             . ILLEGAL INSTRUCTION            CTM10225
00355       000232 53 0 3 0 0 0 000214            J         CTKLAS2Z         .                                CTM10226
00356       000233 10 0 0 0 0 000006     CTKLAS2C LA        A0,6             . OPERAND READ                   CTM10227
00357       000234 53 0 3 0 0 0 000214            J         CTKLAS2Z         .                                CTM10228
00358       000235 10 0 0 0 0 000011     CTKLAS2D LA        A0,011           . OPERAND WRITE                  CTM10229
00359       000236 53 0 3 0 0 0 000214            J         CTKLAS2Z         .                                CTM10230
```

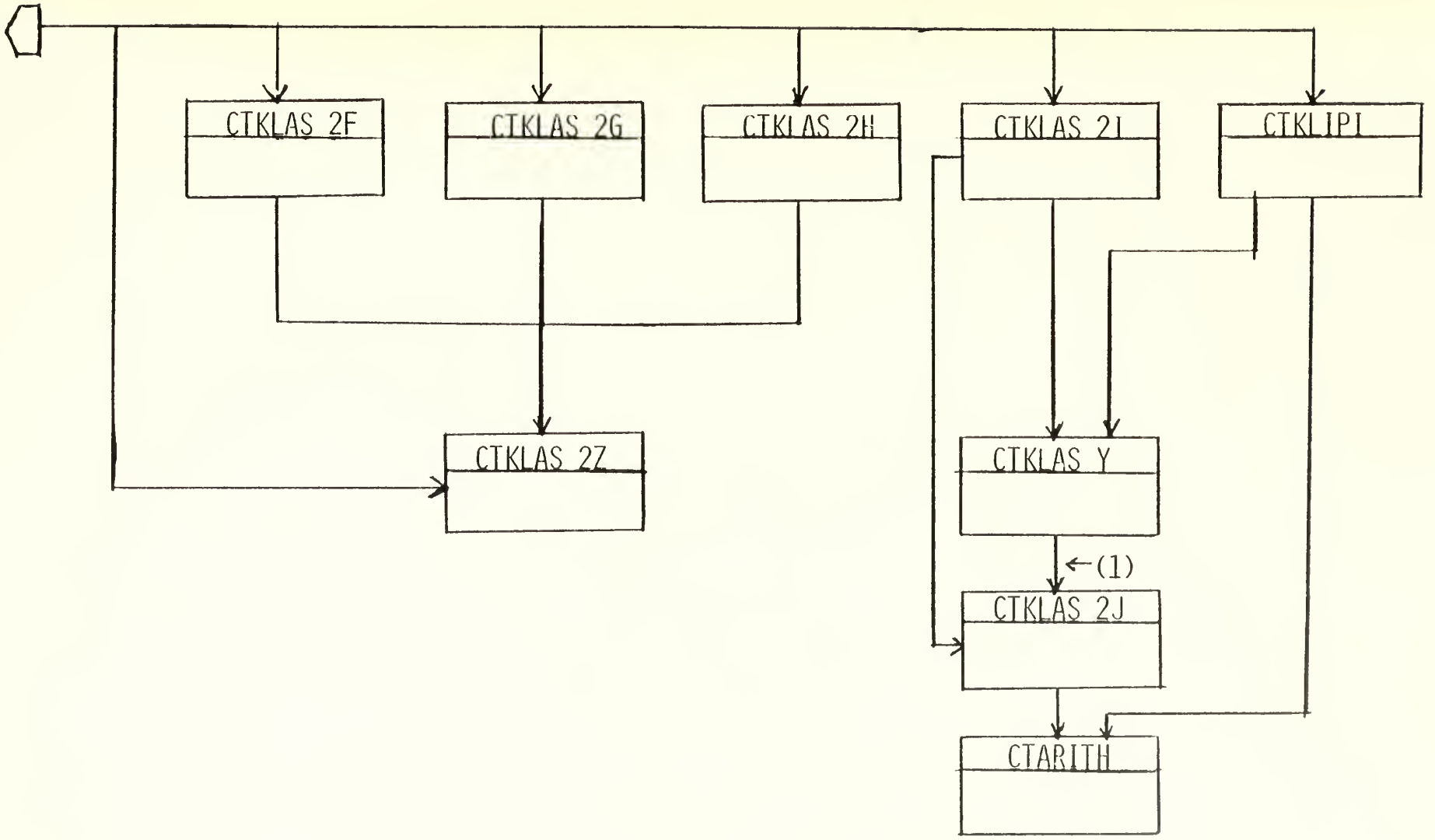
```
ID    F R IC  ADDR   F  A K B I   SY      LABEL     OP CODE  OPERAND                  COMMENTS                        SEQUENCE

00360        000237 10 0 0 0 0 000012   CTKLAS2E  LA       A0,012                   . OPERAND LIMIT                 CTM10231
00361        000240 53 0 3 0 0 0 000214           J        CTKLAS2Z                 .                               CTM10232
00362        000241 10 0 0 0 0 000015   CTKLAS2F  LA       A0,015                   . INSTRUCTION EXECUTE           CTM10233
00363        000242 53 0 3 0 0 0 000214           J        CTKLAS2Z                 .                               CTM10234
00364        000243 55 47 0 0 000522    CTKLAS2G  LCI      047,CTDUMPR1             . RESTORE SI TO P-STORE         CTM10235
00365        000244 10 0 0 0 0 000016             LA       A0,016                   . INSTRUCTION LIMIT             CTM10236
00366        000245 53 0 3 0 0 0 000214           J        CTKLAS2Z                 .                               CTM10237
00367        000246 55 47 0 0 000523    CTKLAS2H  LCI      047,CTDUMPR2             . RESTORE SI TO P-STORE         CTM10238
00368        000247 10 0 0 0 0 000017             LA       A0,017                   . CP MONITOR CLOCK              CTM10239
00369        000250 55 10 0 0 000526              LCI      010,CTCLK                . LOAD CP MONITOR CLOCK         CTM10191
00370        000251 53 0 3 0 0 0 000214           J        CTKLAS2Z                 .                               CTM10240
00371        000252 20 7 0 0 0 000100   CTKLAS2I  LB       B7,0100                  . SAVE EXEC REGISTERS           CTM10241
00372        000253 20 1 0 0 0 000000             LB       B1,0                     .                               CTM102411
00373        000254 23 0 3 0 0 000521             SB       B0,CTERFLAG,K3           . CLEAR FLAG                    CTM102412
00374        000255 07 7 6 0 0 000001             RP       7,1                      .                               CTM10242
00375        000256 57 00 1 0 000531              SCI      A0,CTREGSTR,B1           .                               CTM10243
00376        000257 20 7 0 0 0 000010             LB       B7,010                   . LOAD WITH ZEROES ES21         CTM10244
00377        000260 07 7 6 0 0 000000             RP       7                        .                               CTM10245
00378        000261 55 00 0 0 000527              LCI      A0,CTOMPAT               .                               CTM10246
00379        000262 20 7 0 0 0 000067             LB       B7,067                             .                   ''ES21''
00380        000263 07 7 6 0 0 000000             RP       7                                  .                   ''ES21''
00381        000264 55 11 0 0 000527              LCI      011,CTOMPAT                        .                   ''ES21''
00382        000265 20 7 0 0 0 000100             LB       B7,0100                  . STORE AWAY                    CTM10247
00383        000266 20 1 0 0 0 000000             LB       B1,0                     .                               CTM102471
00384        000267 07 7 6 0 0 000001             RP       7,1                      .                               CTM10248
00385        000270 57 00 1 0 000631              SCI      A0,CTEMPSTR,B1           .                               CTM10249
00386        000271 20 7 0 0 0 000100             LB       B7,0100                  . CHECK THEM                    CTM10250
00387        000272 23 0 3 0 0 000641             SB       B0,CTEMPSTR+010,K3       .                             ''ES21''
00388        000273 20 1 0 0 0 000000             LB       B1,0                     .                               CTM102501
00389        000274 07 0 6 0 0 000001             RP       0,1                      .                               CTM10251
00390        000275 10 0 3 1 0 000631             LA       A0,CTEMPSTR,K3,B1        .                               CTM10252
-> 00391     000276 52 7 1 0 0 0 000335           JBNZ     B7,(CTKLASY)             . GO IF ERROR                   CTM10253
00392        000277 20 7 0 0 0 000100             LB       B7,0100                  . CHECK WITH ONES               CTM10254
00393        000300 07 7 6 0 0 000000             RP       7                        .                               CTM10255
00394        000301 55 00 0 0 000517              LCI      A0,CTONES                .                               CTM10256
00395        000302 20 7 0 0 0 000100             LB       B7,0100                  . TO TEMPORARY STORAGE          CTM10257
00396        000303 20 1 0 0 0 000000             LB       B1,0                     .                               CTM102571
00397        000304 07 7 6 0 0 000001             RP       7,1                      .                               CTM10258
00398        000305 57 00 1 0 000631              SCI      A0,CTEMPSTR,B1           .                               CTM10259
00399        000306 20 7 0 0 0 000100             LB       B7,0100                  . CHECK THEM                    CTM10260
00400        000307 20 1 0 0 0 000000             LB       B1,0                     .                               CTM102601
00401        000310 07 7 6 0 0 000001             RP       7,1                      .                               CTM10261
00402        000311 14 0 3 1 0 000631             AA       A0,CTEMPSTR,K3,B1        .                               CTM10262
00403        000312 13 0 3 0 0 000535             ANA      A0,CTCONST1,K3           .                               CTM10263
-> 00404     000313 51 0 3 0 0 0 000335           JNZ      A0,(CTKLASY)             .                               CTM10264
00405        000314 20 1 0 0 0 000000   CTKLAS2J  LB       B1,0                     . RESTORE ORIGINAL CONTENTS     CTM10265
00406        000315 20 7 0 0 0 000100             LB       B7,0100                  .                               CTM10266
00407        000316 07 7 6 0 0 000001             RP       7,1                      .                               CTM10267
00408        000317 55 00 1 0 000531              LCI      A0,CTREGSTR,B1           .                               CTM10268
00409                                   . ***PERIODIC TESTS PASSED                                                  CTM10269
00410                                   . *
00411                                   . PPPPPPPPPPPPPPPPPPPPPPPPPP..II-H007 -01**PPPPPPPPPPPPPPPPPPPPPPPPPPP  P
```

```
 ID  E F AC  ADDR  F  A K B I  SY     LABEL    OP CODE    OPERAND          COMMENTS                          SEQUENCE
00412                                CTKL2XIT.                                                             P
00413                                , PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
00414                                , *
00415      000320 55 00 0 0 0 000514         LCI      A0,CTINTEM3       , RESTORE EXEC REGISTERS          CTM10270
00416      000321 55 44 0 0 0 000512         LCI      044,CTINTEM1      ,                                 CTM10271
00417      000322 55 21 0 0 0 000513         LCI      021,CTINTEM2      ,                                 CTM10272
00418      000323 55 45 0 0 0 000547         LCI      045,CTASK         , ASK = 0                         CTM10273
00419      000324 42 00 0 0 0 000521         BC       0,CTERFLAG        , SEND ERROR MESSAGE              CTM10274
00420      000325 53 1 1 0 0 0 000327        JE       CTXIT0            , NO-JUMP                         CTM10275
00421      000326 55 45 0 0 0 000510         LCI      045,CTASK1        , ASK MAINTAIN LOCKOUT            CTM10276
00422                                CTXIT0   .        COMPLETE STATE SWITCH                             CTM10277
00423      000327 55 47 0 0 0 000731         LCI      047,CTPSTR4       , STALL                           CTM10278
00424      000330 07 0 5 0 0 0 000000        IR                         , GO TO TASK                      CTM10279
00425      000331 42 00 0 0 0 000521 CTXIT   BC       0,CTERFLAG        , NEED ERROR MESSAGE              CTM10280
00426      000332 53 0 1 0 0 0 000337        JNE      CTPERROR          ,                                 CTM10281
00427      000333 52 1 0 0 0 0 000415        LBJ      B1,CTARITH        ,                                 **ESOR2**
00428      000334 07 0 0 0 0 0 000004 CTXIT1  XS       S$EXIT            , EXIT                            CTM10282
00429      000335 53 4 3 0 0 0 000051 CTKLASY JSC      4,CT4STOP         , 4 STOP ON ERROR DETECTION       CTM10283
00430      000336 53 0 3 0 0 0 000314         J        CTKLAS2           , FINISH RESTORING REGISTERS      CTM10284
00431      000337 20 4 0 0 0 000005 CTPERROR  LS       04,5              , SET FLAG                        CTM10285
00432      000340 32 02 0 0 0 000521         BZ       2,CTERFLAG        , CLEAR DEFERRED ERROR            CTM10286
00433      000341 53 0 3 0 0 0 000056        J        CTMERR1           , PICK ERROR MESSAGE              CTM10287
00434      000342 000000020000 CTDEFSTR      +020000                    , 1 SEC. BETWEEN SLICES          CTM10288
00435      000343 000000240000               +024000                    , 10 SEC. BETWEEN USES           CTM10289
00436      000344                            RES  * 34                  , DEFERRED SAVE AREA              CTM10290
00437      000400 05 0 0 0 0 000473 CTDEF     DL       A0,CT2SPAT        ,                                 CTM10303
00438      000401 71 2 2 2 0                 HAH      A2,A2             ,                                 CTM10304
00439      000401 64 3 0 40                  HRZ      A3,32             ,                                 CTM10305
00440      000402 71 2 1 0 0                 HA       A2,A0             ,                                 CTM10306
00441      000402 71 3 2 1 0                 HAH      A3,A1             ,                                 CTM10307
00442      000403 70 3 2 0 0                 HCP      A3                ,                                 CTM10308
00443      000403 61 04 0 0                  HLCT     A4,A0             ,                                 CTM10309
00444      000404 61 05 1 0                  HLCT     A5,A1             ,                                 CTM10310
00445      000404 74 0 4 2 0                 HC       A0,A2             ,                                 CTM10311
00446      000405 53 0 1 0 0 0 000413        JNE      CTDEFERR          ,                                 CTM10312
00447      000406 74 3 4 5 0                 HC       A3,A5             ,                                 CTM10313
00448      000407 53 0 1 0 0 0 000414        JNE      CTDEFERR          ,                                 CTM10314
00449      000410 71 2 2 4 0                 HAH      A2,A1             ,                                 CTM10315
00450      000410 71 3 2 5 0                 HAH      A3,A5             ,                                 CTM10316
00451      000411 56 2 3 0 0 0 000413        DJNZ     A2,CTDEFERR       ,                                 CTM10317
00452      000412 07 0 4 0 0 0 000004        XS       S$EXIT            ,                                 CTM10320
00453      000413 33 01 0 0 0 000521 CTDEFERR BS       01,CTERFLAG       , SET ERROR FLAG                  CTM10321
00454      000414 07 5 0 0 0 000004          XS       S$EXIT            ,                                 CTM10322
00455                                CTARITH  , 401    ARITHMETIC TEST   ,                                 **ESOR2*
00456      000415 05 0 0 0 0 000473          DL       A0,CT2SPAT        ,                                 **ESOR2**
00457      000416 05 2 0 0 0 000473          DL       A2,CT2SPAT        ,                                 **ESOR2**
00458      000417 05 4 0 0 0 000473          DL       A4,CT2SPAT        ,                                 **ESOR2**
00459      000420 05 6 0 0 0 000473          DL       A6,CT2SPAT        ,                                 **ESOR2**
00460      000421 63 0 0 40                  MDLC     A0,32             ,                                 **ESOR2**
00461      000421 74 0 4 7 0                 HC       A0,A7             ,                                 **ESOR2**
00462      000422 53 0 1 0 0 0 000427        JNE      CTARITH2          ,                                 **ESOR2**
00463      000423 63 2 0 41                  MDLC     A2,33             ,                                 **ESOR2**
```



REVISED FIGURE 4.2 CT HIERARCHICAL STRUCTURE (2 OF 5)
REVISED Page 4-5



(1) USED ONLY WHEN A 4 STOP CONDITION DOES NOT EXIST.

REVISED FIGURE 4.2 CT HIERARCHICAL STRUCTURE (5 OF 5)

REVISED Page 4-8

REFERENCES

1. Oxman, Steven W., "Fiscal Year 1979 CCSMA System-Level Software Maintenance Approach and Transition Plan," March 20, 1979, (Revision E), Software Systems Department, Trident, CCSMA, New port, RI.

2. Oxman, Steven W., "The Testing of the Trident Command and Control System," Workshop on Software Testing and Test Documentation, December 1978, Digest.

3. Chapin, Ned, "Flowcharting with the ANSI Standard: A Tutorial," Computing Surveys, ACM, June 1970, Volume 2, No. 2.

DISCLAIMER

The opinions expressed in this report are strictly those of the author and do not necessarily reflect the opinions of the Naval Postgraduate School, Department of the Navy, or Department of Defense.

DISTRIBUTION LIST

	No. Copies
Prof. Lyle Cox Code 52Cl Computer Science Department Naval Postgraduate School Monterey, CA 93940	1
Mr. William Ferreria Trident CCSMA Building 12 U.S. Navy Newport, RI 02840	1
Mr. Gerald Goulet Naval Air Development Center Warminster, PA 18974	1
Prof. Carl R. Jones Code 54Js Administrative Sciences Department Naval Postgraduate School Monterey, CA 93940	1
Prof. Norman Lyons Code 54Lb Administrative Sciences Department Naval Postgraduate School Monterey, CA 93940	1
LCDR Ronald W. Modes Code 52Mf Computer Science Department Naval Postgraduate School Monterey, CA 93940	1
Mr. Steven Oxman Trident CCSMA Building 132T U.S. Navy Newport, RI 02840	1
Mr. Richard Pariseau Naval Air Development Center Warminister, PA 18974	1

	No. Copies
Prof. Norman F. Schneidewind Code 54Ss Administrative Sciences Department and Computer Science Department Naval Postgraduate School Monterey, CA 93940	10
Dr. John Stancil Trident CCSMA Building 132T U.S. Navy Newport, RI 02840	1
Prof. Roger Weissinger-Baylon Code 54Wr Administrative Sciences Department Naval Postgraduate School Monterey, CA 93940	1
AS/OR Library Code 54/55 Naval Postgraduate School Monterey, CA 93940	1
Computer Center Library Code 0141 Naval Postgraduate School Monterey, CA 93940	2
Computer Science Department Code 52 Naval Postgraduate School Monterey, CA 93940	2
Defense Technical Information Center Cameron Station Alexandria, VA 23314	2
Knox Library Code 0142 Naval Postgraduate School Monterey, CA 93940	4
Office of Research Administration Code 012A Naval Postgraduate School Monterey, CA 93940	1